Syracuse University researchers explore Ghana's Lake Bosumtwi to learn about tropical climate change and the effects of a meteorite strike

SECRETS of a Crater Lake

By Judy Holmes

Photography by Peter Cattaneo

As the sun rose over picturesque Lake Bosumtwi, a team of Syracuse University researchers prepared for another day of using state-of-the-art equipment to help unlock the mysteries hidden below the lake bottom. Nestled in the heart of Ghana, the lake holds an untapped reservoir of information that could help scientists predict future climate changes by looking at evidence from the past. This information will also improve the scientists' understanding of the changes that occur in a region struck by a massive meteorite.

The project, led by earth sciences professor Christopher Scholz of the College of Arts and Sciences and funded by the National Science Foundation (NSF), is the first large-scale effort to study Lake Bosumtwi, which formed 1.1 million years ago when a giant meteor crashed into the Earth's surface. The resulting crater is one of the largest and most well-preserved geologically young craters in the world, says Scholz, who is collaborating on the project with researchers from the University of Arizona, the University of South Carolina, the University of Rhode Island, and several Ghanaian institutions. "Our data should provide information about what happens when an impact hits hard, pre-Cambrian, crystalline rocks that are a billion years old," he says.

Earth sciences professor Christopher Scholz and his research team use the specially equipped *R/V Kilindi* to perform climate studies on Lake Bosumtwi in Ghana.

Equally important is the fact that the lake, which is about 8 kilometers in diameter, has no natural outlet. The rim of the crater rises about 250 meters above the water's surface. Streams flow into the lake, Scholz says, but the water leaves only by evaporation, or by seeping through the lake sediments. For the past million years, the lake has acted as a tropical rain gauge, filling and drying with changes in precipitation and the tropical climate. The record of those changes is hidden in sediment below the lake bottom. "The lake is one of the best sites in the world for the study of tropical climate changes," Scholz says. "The tropics are the heat engine for the Earth's climate. To understand global climate, we need to have records of climate changes from many sites around the world, including the tropics."

Before the researchers could explore the lake's subsurface, they needed a boat with a large, working deck area that could carry eight tons of scientific equipment. The boat—dubbed *R/V Kilindi*—was built in Florida last year. It was constructed in modules that were dismantled, packed inside a shipping container, and reassembled over a 10-day period in late November and early December 1999 in the rural village of Abono, Ghana. The research team then spent the next two weeks testing the boat and equipment before returning to the United States for the holidays.

In mid-January, five members of the team—Keely Brooks, an earth sciences graduate student; Peter Cattaneo, a research analyst; and Kiram Lezzar, a postdoctoral scholar, all from SU; James McGill, a geophysical field engineer; and Nick Peters, a Ph.D. student in geophysics from the University of Miami—returned to Abono to begin collecting data about the lake's subsurface using a technique called seismic reflection profiling. In this process, a high-pressure air gun is used to create small, pneumatic explosions in the water. The sound energy penetrates about 1,000 to 2,000 meters into the lake's subsurface before bouncing back to the surface of the water. The reflected sound energy is detected by underwater microphones—called hydrophones—embedded in a 650-meter-long cable that is towed behind the boat as it crosses the lake in a carefully designed grid pattern. On-board computers record the signals, and the resulting data are then processed and analyzed in the laboratory. "The results will give us a good idea of the shape of the basin, how thick the layers of sediment are, and when and where there were major changes in sediment accumulation," Scholz says. "We are now developing a three-dimensional perspective of the lake's subsurface and the layers of sediment that have been laid down."

Team members spent about four weeks in Ghana collecting the data. They worked seven days a week, arriving at the lake just after sunrise. On a good day, when everything went as planned, the team could collect data and be back at the dock by early afternoon. Except for a few relatively minor adjustments, the equipment and the boat worked well. Problems that arose were primarily non-scientific—tree stumps, fishing nets, cultural barriers, and occasional misunderstandings with local villagers.

Lake Bosumtwi, the largest natural freshwater lake in the country, is sacred to the Ashanti people, who believe their souls come to the lake to bid farewell to their god. The lake is also the primary source of fish for the 26 surrounding villages. Conventional canoes and boats are forbidden. Fishermen travel on the lake by floating on traditional planks they propel with small paddles. Before the research project could begin, Scholz and his Ghanaian counterparts had to secure special permission from tribal chiefs to put the *R/V Kilindi* on the lake.

When the team began gathering data, rumors flew around the lake as to why the researchers were there. "Some thought we were dredging the lake for gold, others thought we were going to drain the lake or that we had bought the lake," Cattaneo says. "But once the local people understood why we

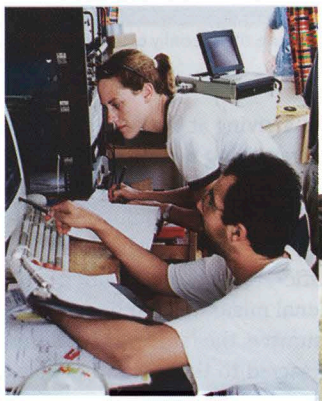
Earth sciences professor Christopher Scholz, far right, meets with tribal chiefs to receive their permission to put the *R/V Kilindi* on Lake Bosumtwi.

were there, they were very helpful."

One of the team's main problems was navigating the labyrinth of fishing nets that criss-cross the lake's surface. To collect data, the boat had to travel in as straight a line as possible across the entire length of the lake. The sensitive equipment embedded in the 650-meter cable would be damaged if it got tangled in the nets, so the team worked with fishermen to clear the nets as the boat went across the lake. It was often a slow, tedious process. "After all was said and done, we were successful," Brooks says. "We got the data."

For Brooks, a second-year master's degree student, the experience was an unprecedented opportunity to do fieldwork on a major research project in a virtually unstudied area. "I have learned more in the past year than I did during my whole undergraduate career," she says.

Brooks will process much of the data in the team's SU laboratory—under the guidance of Lezzar and Cattaneo—using a technique called seismic reflection analysis. She worked with Scholz during the spring semester to learn the technique and also took a course on the topic at Cornell University. After processing, the data will be used to create maps of the sedimentary layers of the lake's subsurface. The data will also provide scientists with a three-dimensional perspective of the crater. "The data should tell us a lot about what happens to the Earth when a major meteorite hits," Scholz says. "The information we collect will be of tremendous benefit to an international, interdisciplinary group of scientists, including planetary geologists, paleontologists, and scientists from NASA."



Preliminary analysis of the data, which was completed in May, uncovered the first documented central uplift of an impact crater, Scholz says. Scientists believe a crater's shape depends on the size of the meteor. Smaller impacts are believed to create a simple bowl-shaped crater, while larger impacts may create a more complex crater featuring a central cone-like structure. Until now, such structures have not been documented in craters on Earth, Scholz says. Scientists believe the meteor that formed Lake Bosumtwi was about 500 meters in diameter, or about the size of 5 football fields, and that the impact was intense enough to create the central uplift seen in the data analysis. As more of the data is analyzed, additional details about the central uplift and the crater's structure are expected to emerge, Scholz says.

In late May, with preliminary maps in hand, Scholz returned to Lake Bosumtwi with a team of eight researchers to obtain core samples of the lake's sediment. The other leaders of that expedition were John King, professor of oceanography at the University of Rhode Island Graduate School of Oceanography, and Jonathon Overpeck, director of the Institute for Studies of the Planet Earth at the University of Arizona. Some of the core material will be analyzed at SU. "Analyzing the sediment is like reading tree rings," Scholz says. "It is one piece of the puzzle in determining climate conditions during the past million years. The sediment cores give us a one-dimensional perspective, while the seismic profiles give us two-dimensional perspectives across the entire basin."

After they obtained the cores, the team disassembled the *R/V Kilindi* and packed it back into the shipping crates. The boat and equipment were then shipped to Uganda for an upcoming project. Scholz also plans to use the equipment next year on Lake Malawi in East Central Africa, where he is a principal investigator on another major NSF climate study grant. "The boat can be used for a variety of scientific studies," Scholz says. "We're hoping to develop this modular vessel into a national facility for lake research."

At right, SU research team members Keely Brooks and Kiram Lezzar unwind cable, embedded with underwater microphones to record sound energy, into Lake Bosumtwi. Above, Brooks and Lezzar examine data being recorded from signals picked up by the underwater microphones.

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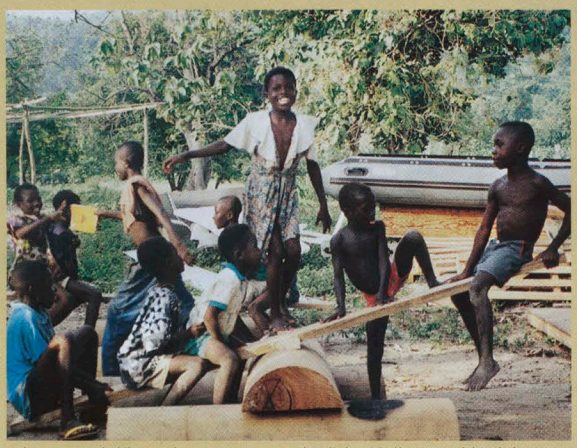
—Christopher Scholz
SU earth sciences professor

Sharing

SEESAWS, SWINGS, AND SMILES WITH GHANAIAN CHILDREN

Phillip Arnold arrived in Abono, Ghana, armed with 13 pounds of hard candy and a pile of toys his children had collected from McDonald's Happy Meals to share with village children. He left the small East African fishing village with deep bonds of friendship forged with people living half a world away from his Syracuse home. "The people there share everything," says Arnold, a laboratory manager for the earth sciences department in the College of Arts and Sciences. "They are very open, affectionate, caring people who look out for each other."

Arnold was part of the SU research team—led by earth sciences professor Christopher Scholz—working on a study of climate change in the tropics over the past million years by using information hidden in the lake's sediment. Arnold, who helped build the research team's boat, says children and adults gathered every day to watch the crew, and he soon noticed how quiet the children were. "The kids would sit around with nothing to do," he says. "They didn't have anything to play with."



Ghanaian children play on a seesaw built by Phillip Arnold, a lab manager for the earth sciences department.

On his third day in Abono, Arnold took a break, jumped off the boat, and began cutting scrap wood into blocks of varying shapes and sizes. He threw them into a box and gave them to the children to play with. From that moment on, Arnold and the village children became inseparable. By the time he left, the villagers called him *agyema,* which means "father of the children."

Arnold and his co-workers helped the children transform the crew's work area, which was cluttered with village debris and other materials, into a park. The group made park benches out of logs, and Arnold used scrap wood and logs to construct five seesaws for the park. He also built a tree swing from chain, rope, and wood scraps. "It was a novelty," he says. "They had never seen a swing before."

The children were so excited about the park that they began to skip school to play there. The village elders ruled that the swing had to be rendered unusable during school hours. To help resolve the problem, Arnold built a swing and seesaw at the school.

Word of Arnold's knack for making useful things from scraps quickly spread, and villagers asked him for help building tables and other furnishings. One of the more unusual requests was for a hinged moneybox that the villagers use to collect funeral donations. He also made writing boards for the children to use in school. Unsatisfied with those he made of scrap wood, Arnold bought plywood and set up a makeshift writing-board assembly line to produce 36 boards for the school—a rundown, wood-frame building that lacks adequate desks, books, and supplies.

After returning to Syracuse, Arnold organized a book drive at St. Matthew's School in East Syracuse, the elementary school his children attend. He also bought pencils, sidewalk chalk, paper, art supplies, and bubble-blowing toys, and collected 10 soccer balls donated by local Hess gas stations. The supplies were delivered to Abono in mid-January when the research team returned to begin its experiments. "The most fun I've had in my life was teaching the kids how to use the seesaws," Arnold says.

—*Judy Holmes*